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A Description of Two New Genera and Species of Phreatoicidea, with a Discussion of the Affinities of the Members of this Family, by George E. Nicholls.

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Contents:

On the occasion of a short visit made to Victoria in February of this year, I collected, during a week-end at Mt. Buffalo, a number of specimens of a species of *Phreatoicus*, with quite small eyes. These, while bearing a marked general resemblance to *P. australis*, seemed nevertheless to differ from that form in quite a number of features. Since but one other species (*P. shephardi*, which is eyeless), has been described, hitherto, from the eastern part of the Australian mainland, it was likely that these specimens would prove to be referable to a new species and, accordingly, as many as possible were secured.

They occurred in a variety of situations; the first, a solitary specimen, was caught in the waters of Lake Catani, its presence there probably accidental, for prolonged search failed to reveal others

there or under similar conditions in the waters of the New Reservoir. They were discovered, however, quite abundantly, partly embedded in almost dry mud which had formed the floor of a shallow puddle, at a spot where, in wetter seasons, a small creek discharged into the Lake. Here, under one quite small piece of decaying bark, nearly forty specimens were found curled up and motionless.* This creek, on investigation, was found to serve, in normal seasons, as the drain for a peat bog, under the mossy surface off which and in a small spring-fed hollow yet other specimens were taken. On the following day, the "Crystal Brook" was followed to its source, near which, in tiny hollows between clumps of sphagnum, as well as in a narrow runnel emptying into the Brook, other, lighter-coloured specimens were captured. Another trip, this time to the "Horn," for the most part following the course of a small creek which proved to have its origin in a considerable bog that partly encircled the foot of the peak itself (where this rises abruptly from the Plateau), was equally successful. On this occasion *Phreatoicus* was taken at a number of different spots, as well as quite freely in the bog at the foot of the "Horn," practically at the highest part of the Plateau. Indeed, several of the localities must have been at altitudes closely approaching five thousand feet.

The specimens taken from black peaty mud or from beneath the surface of the bog were much darker in colour and for the most part were densely infested with attached Rotifers, as well as by disc-shaped bodies which I fail to identify. In some cases a single seta may have its half-dozen attached forms, and these may largely obscure the actual outline in setose regions. Others, taken from the open, are lighter coloured and much less heavily infested.

So plentiful as was this animal, of such conspicuous size (exceeding 14 mm.), and with so widespread an occurrence, it seemed almost incredible that it could have escaped earlier observation. Accordingly, on my return to Melbourne, I made enquiry at the Museum, where I learned that there were apparently no records of specimens of *Phreatoicus* from the Buffalo region. I was, however, very kindly permitted to examine the Museum Collection of Freshwater Crustacea and satisfy myself of the absence of any such material from that part of Victoria. While engaged upon this search I happened upon a tube containing another Phreatoicid, unnamed, but, beyond all peradventure, new. This bore a locality label which indicated that the contained specimens were collected in

*Some of these, kept under similar conditions, in a small wooden box, survived until my return to Perth, nearly three weeks later, when, on being placed in water, they shortly unrolled and resumed active existence.

the Northern Territory, the first instance of a Phreatoicid from the Tropics. Hitherto, the most northerly records for this family were the Barrington Tops in N.S.W., S. Lat. 32°, Perth, in W.A., in the same Latitude, while *P. latipes* from South Australia was found at Coward, 29° South Latitude. The fossil form, discovered at Newtown, Sydney quite probably ranged as far north as these.

At my request, I was most courteously allowed to remove certain of these Northern Territory forms for examination. They are described below, a new genus being required for their reception, the species being named in compliment to Mr. Kershaw. The species, taken at the Buffalo proved, likewise, to be new, this being named after my friend and enthusiastic fellow collector, Mr. A. E. Joyner, of Perth.

A consideration of these two new forms and a review of the structure of such other species as I have been able to examine, has convinced me that the Australasian species referred, hitherto, to the genus *Phreatoicus,* fall into two quite definite and readily separable groups, sufficiently distinct to warrant their assignment to separate genera.

As was stated in an earlier paper (1924), it was only after very considerable hesitation that I had referred the Western Australian form *P. lintoni* to the genus *Phreatoicus,* a hesitation which Dr. Chilton had previously experienced when describing *P. latipes.*

Accordingly, I now propose to establish for all the lowland forms from Western and Southern Australia, a new genus **Amphisopus,** all these species having in common a number of features elsewhere found together only in the Amphipoda. To this new genus, however, the species from the Northern Territory cannot be assigned, nor does it fall within the accepted definition of *Phreatoicus;* consequently the recognition of a second new genus seems necessary and for this I propose the name **Eophreatoicus.** The remaining forms, distributed in the subterranean and surface waters of New Zealand, the Highlands of Tasmania, and the Sub-Alpine regions of Eastern Australia should, so far as I can judge, be retained in the genus *Phreatoicus* Chilton, the new species *P. joyneri,* also, properly belonging here. The position of *P. capensis* Barnard is uncertain, and in the absence of material I can come to no conclusion, but, judging from Barnard's figures (1914, Pl. 23, 24) and his descriptions, I incline to the opinion that it will be found to occupy a position intermediate between *Eophreatoicus* and *Phreatoicus.* In some respects, indeed, it appears actually more primitive than either of these; a consideration of this matter is deferred, however, to a later chapter, where the inter-relationships of the several forms are discussed.

AMPHISOPUS, gen. nov.

Body long, peraeon sub-cylindrical, pleon markedly compressed. First segment short, more or less fused with the head, which lacks a vertical groove near its posterior margin. Upper antenna filiform, longer than peduncle of lower antenna, flagellum with ten or more joints. Lower antenna long, flagellum many jointed. Eyes large. Mandibles with an appendage, right mandible retaining a reduced secondary dentate edge. First maxilla with six or seven plumose setae on inner lobe. Legs divided into an anterior series of four and a posterior series of three, the coxal joints scarcely or not distinct. First pair of legs sub-chelate in both sexes, larger in the male than in the female; the fourth leg in the male not sub-chelate; basos of the three legs of the posterior series largely expanded. Pleon relatively longer than in *Phreatoicus;* the last segment almost, or completely, marked off from the telson. Coupling hooks on the basal joint of pleopods one and two; epipodites upon the third, fourth and fifth pleopods. In the male, a strongly curved penial filament on the endopodite of second pleopod, long and pointed, without terminal setae. Male appendage not setose. Uropods stout, biramous, styliform. Telson large, horse-shoe shaped in transverse section, in profile suggesting a sub-conical body, without terminal projection, the dorsal margin entire, emarginate or cleft.

With three species:—

A. lintoni Nicholls (sp. typ.), *Phreatoicus l.,* Nicholls, 1924, Jour. Roy. Soc, W.A., Vol. X, pp. 89-104, 1924.

A. latipes (Chilton), 1923, *Phreatoicus l.,* Chilton, Trans. Roy Soc. S.A., Vol. 46, p. 23, Figs. 1-14; *P.l.,* Glauert, Jour. Roy. Soc., W.A., Vol. X, pp. 49-57, 1924; *P.l.,* Nicholls, Jour. Roy. Soc., W.A., Vol. X, Pl. 8, Fig. 3a, pp. 98-104, 1924.

A. palustris (Glauert), 1924, *Phreatoicus p.,* Glauert, 1924, Jour. Roy. Soc., W.A., Vol. X, pp. 49-57; *P.p.,* Nicholls, Jour. Roy. Soc., W.A., Vol. X, Pl. 8, Figs. 2, 2a, pp. 98-104, 1924.

Distribution. At the time when the original description of *A. lintoni* was written I had obtained my material from but a single locality, a small creek emptying into the estuary of the King River in South-Western Australia. Subsequent collecting trips showed that this species occurs freely in and around Albany itself, one fine specimen actually being taken in the Marine Drive, and more than a dozen different spots yielded abundant material. In some case these were found plentifully in mere puddles along the railway line, or in larger hollows at the foot of the hill near the swamps at the landward end of the Deep Water Jetty. Some of my larger specimens were taken practically at sea level, in a tiny runnel of fresh water within a half dozen paces of the spot where this discharged into the

sea. Yet others were secured from a small pool fed by a spring beneath a huge granite boulder, high up on the southern slopes of Mt. Clarence (Albany) and in its swampy overflow. A later trip made, in January, 1923, to Two People Bay, some thirty miles or so to the Eastward of Albany, resulted in the discovery of this species as an abundantly occurring form in that locality.

At Denmark, thirty miles to the West of Albany, and at other places still more westwardly, to Nornalup (nearly eighty miles), I have, however, searched in vain for this Phreatoicid, nor has it been found in the relatively abundant fresh waters of the Porongorup Ranges, some forty miles inland. Nor yet has any trace of it been seen in the Margaret River district at the southern end of the West Coast.

Amphisopus lintoni, then, may be considered as likely to prove a relatively widespread form occurring in shallow fresh waters *near to the Coast* of South-Western Australia from the vicinity of Albany eastwards, but probably not existing in the dark peaty waters (locally, "coffee" water) of the more western creeks and streams.

The known range of *A. palustris*, too, is now greatly extended. It has been taken freely in many of the shallow lakes in the environs of Perth. I have collected it, also, from swamps and ditches at Pinjarra, nearly sixty miles to the south, and near to York, some forty miles inland. In these two latter cases there are exhibited differences which may prove to be of varietal value.

Concerning *A. latipes* nothing further has been recorded since the publication of Chilton's paper in 1923.

Habits. An account of the habits of these and other Phreatoicids will be found below.

Phreatoicus joyneri sp. nov., Plates XXV, XXVI, and Pl. XXIX, Figs. 40-44.

Specific Diagnosis. Body robust, surface smooth, with very few scattered hairs. Head somewhat shorter than combined length of first and second peraeon segments, produced into postero lateral lobe, which touches maxilliped, with well marked vertical groove slightly proximal to hinder border. Eyes small, round, with few ommatidia.

Peraeon sub-cylindrical. Epimera (coxal joints) well developed. First segment very short in mid dorsal line, longer on ventral border, scarcely fused with the head, second, third, and fourth segments equal, fifth and sixth equal but shorter, seventh distinctly shorter.

Pleon moderately long, having, with the telson, a length almost

exactly two thirds of that of combined cephalon and peraeon. First segment as short as first peraeon segment, second and third equal and longer than the first, fourth longer than preceding, the fifth deeply notched posteriorly and twice the length of the fourth. The setal fringe practically confined to inferior margin. The ventral border of the sixth pleon segment armed ventrally with stout pectinate setae, which give place to spines at the postero-lateral corner; its overlapping posterior pleural border fused with the telson and forming a short sutural line bearing but three fine setae.

Telson large, horse-shoe shaped in transverse section, a well developed dorsal transverse depression defining the tip-tilted terminal projection, the latter armed with spines and setae and flanked on either side, at a slightly lower level, with strong spines. Ventrally the pleural margin of the telson is free from setae or spines.

First antenna short, not as long as the peduncle of the second, with a flagellum of five joints in the male and but three in the female; second antenna nearly half the length of the animal, almost as long as cephalon and first five peraeon segments, peduncle barely half the length of the flagellum, which may have from eighteen to twenty joints. Right mandible without secondary cutting edge, both mandibles with well developed curved spinous plate bearing a double row of denticulate spines.

Gnathopods strongly sub-chelate, the palm oblique and armed with a series of spines which become broadened toward the proximal end of the joint into subtriangular serrated scutes. Second and third peraeopods appear to be slightly prehensile; the fourth, in the male, quite strongly sub-chelate; in the female, the fourth resembles the preceding; fifth, sixth and seventh legs increasing progressively in length, the subtriangular coxal regions distinctly marked off, but coloured exactly as the related segments; basal joints rounded, little expanded. Pleopods 3-5 with large endopodites; uropods long, peduncle bearing on its extremity, one thick and one slighter spine pectinated dorsally, rami slender, not very spiny.

Colour: Brown, generally very dark, with lighter (yellowish) markings; specimens taken in the open varying with the colour of the underlying mud, to light brownish or even yellowish grey. The legs may then be a light yellow in colour.

Length: Largest specimens (male) 14 to 15mm., none of the much less numerous females exceeding eleven millimetres.

Habitat: Taken in bogs, among the growth of sphagnum, also in weedy runnels among the tufts and roots of grass on the Mt. Buffalo Plateau, Victoria.

Detailed Description.—Eyes: Small, few (12-14) ommatidia,

apparently undergoing degeneration. The *first antenna* (Pl. XXV, Fig. 2, 2a) remarkably short with, in the female, fewer joints than in any species of *Phreatoicus* described hitherto. There is very little to distinguish the peduncle from the flagellum, the penultimate joint of the latter being, in the female, relatively large and swollen, while the terminal joint is a mere knob. In the full grown male there may be either four or five joints, the second and third being subequal and larger than the other joints. Setae are not very abundant, but there is a small terminal tuft and an olfactory cylinder occurs upon both the terminal and the penultimate joint in both sexes.* The *second antenna* (Pl. XXV, fig. 1, and Pl. XXIX, fig. 44) is slightly less than half the length of the body, the peduncle, with five joints, being almost exactly half the length of the flagellum, which has eighteen to twenty long, slender, joints each set with a sub-terminal and incomplete circlet of setae; in the peduncle the first joint is short, the second, third and fourth increase progressively in length, the fifth being slender and as long as the third and fourth together.

The *upper lip* agrees closely with that of *P. australis* (Chilton, 1891, p. 156, Pl. 23, fig. 4). The *mandibles*, also are much as in that species, the right mandible having but three teeth in the cutting edge. The spinous plate, however, on both mandibles (Pl. XXVI, fig. 12, 12a) is a curved structure with a median groove running along its exposed face, on either side of which is a row of stout spines with well marked denticulations; on the left mandible these spines (16-18 in number) appear to be symmetrically arranged and similar, but on the right the spines along one edge (the posterior), are smaller and sharply bent. Between this plate and the molar tubercle are the usual pectinate setae (two or three). On a level with the tubercle are a number of short stiff setae. Upon the palps some of the stoutest setae (Pl. XXVI, fig. 12, s) are strongly serrate on one margin and fringed with fine closely set hairs on the opposite edge. The *lower lip* (Pl. XXVI, fig. 9) differs apparently from that of *P. australis* chiefly in that its inner margins are clothed with longer and stiffer setae.

The *first maxilla* (Pl. XXVI, fig. 8, 8a) also resembles closely that appendage in *P. australis*. Its outer lobe is broad with truncate apex set with eight or nine stout setae, some of which are denticulate. The inner lobe has the usual number (4) of plumose setae, agreeing in this with *P. shephardi*, *P. kirkii* and *P. assimilis*. *P. australis* is

*In Pl. XXI, Fig. 1, the length of the first antenna, relative to the second, has been exaggerated—in its natural position, its apex rarely reaches the terminal joint of the peduncle of the second antenna, its total length only equalling the combined length of the three terminal joints of the peduncle of that appendage.

said to have four or five such setae. In the latter species and in *P. assimilis* there are in addition two simple setae, while in *P. shephardi* none are figured; *P. joyneri* has one only.

The plumose setae in this form, however, are unusually stout and densely set with a terminal tuft of setae (resembling rather the penicilla of Oniscids) and differing in this, if one may judge from the figures, from the other species of *Phreatoicus*. Another difference is furnished apparently by the presence of a curved ridge (Pl. XXVI, fig. 8a) stretching along the surface of the inner lobe and bearing numerous long setae. The structure of the *second maxilla* (Pl. XXVI, fig. 10) of *P. joyneri* is almost exactly that of the corresponding appendage in *P. australis*, excepting that the inner lobe is narrower distally, the outer lobe and the palp having fewer setae, which are pectinate in the usual manner; the usual tuft of setae at the base of the palp is not to be made out.

In the *maxillipeds* (Pl. XXVI, fig. 11) the epipodite is perhaps rather broader and bears but three lateral setae. Upon the inner plate two stout coupling spines only are present and along its whole free border it is fringed with long and stout plumose setae, the apical setae being feebly plumose or pectinated; the inner distal angle, in both meros and carpus is markedly produced.

The *gnathopod* (Pl. XXV, fig. 6) is of the usual sub-chelate type. The limb is stout, the basos having a length barely twice that of its greatest width; the anterior margin of this joint is wholly free from setae, whereas in the succeeding appendages the corresponding joint is strongly setose. In the adult male, the propod has almost exactly the form of the corresponding joint in *P. australis*, but is free from setae on the lateral surfaces, while the posterior border proximal to the palm is almost straight, whereas in *P. australis* it is figured as concave. The *palm* (Pl. XXV, fig. 6a) is raised into a narrow saw-like edge, the simple distal spiniform setae passing into broadened serrate scutes (Sc) at the more proximal end. The *dactyl* has about ten, almost equidistant, setae on its concave (posterior) margin, with four or five on the convex surface. A similar setose condition of the dactyl is figured (Chilton 1894) for *P. assimilis* and described (1891, p. 161) in *P. australis*, but is otherwise unrecorded. There is a small terminal tuft of setae also, one of the these being somewhat similar to the sensory setae found on the first antennae and named "olfactory cylinder." This subapical tuft is present on the succeeding appendages (Pl. XXV, fig. 7a) and, indeed, appears to be of very general occurrence in the Phreatoicidea, though reduced apparently to a single seta in some species (cf. *A. palustris* (Glauert), 1924, fig. 3). In the female, the appendage is very similar, but the propod is rather less strongly developed.

In the male, the three succeeding *peracopods* have apparently developed a prehensile condition, though in varying degrees. In the second thoracic appendage the propod has a sub-rectangular outline, the anterior border being very slightly convex, the posterior with a small distal concavity furnished with setae. Proximally a couple of stout spines would meet the tip of the down-folded dactyl. This joint is stout and curved, its proximal end set in a groove between distally produced extensions of the propod. The propod of the third appendage is rather stouter, more convex anteriorly, its posterior border more concave and bearing two pairs of proximally situated spines to receive the dactyl, with better developed guides for the base of the dactyl. The fourth peracopod has a very stout propod, convex along both borders, greatly produced distally on either side of the dactyl, thus hiding much of the base of this joint, which appears short and is strongly curved. The tip of the dactyl has but a very reduced secondary unguis and is received between a pair of powerful spines on the propod. In all three of these appendages the anterior border of the basos is beset with setae, the posterior border of the entire limb being strongly setose.

The three legs of the posterior group are, also, markedly setose; the basos, narrow at its origin, shows an expansion which is little marked in the foremost, more pronounced in the posterior, limbs; the hinder margin of the joint being furnished with moderately long setae; the large ischios expanded about the middle of its length rather than distally; the meros widened distally; the two succeeding joints sub-rectangular, the propod being long and slender. The dactyl has a small secondary unguis which is flanked by a stout spine and a more slender seta. The coxal joints (epimera) of these thoracic limbs seem to resemble closely those of *P. australis* (Chilton, 1891, Pl. 23, fig. 1).

The paired male appendage (Pl. XXVI, fig. 13) on the last thoracic segment appears to differ from the organ as described and figured in *P. australis* in the possession of a number of setae regularly disposed along its mesial border. Such a condition is figured, however, for *P. capensis*.

Pleopods (Pl. XXVI, figs. 14-16). The branchial appendages likewise differ somewhat from these structures in other species of *Phreatoicus*. In the first pair (Pl. XXVI, fig. 16) the number (13-14) of plumose setae is rather greater than in *P. australis*. The endopodites of the second (Pl. XXVI, fig. 14) are relatively longer, reaching to the end of the proximal joint of the exopodite and are scarcely exceeded by the slightly curved penial filament, which bears a terminal tuft of four or five stiff setae. The distal lobe of the exopodite is fringed with about twenty plumose setae, while internal to its base, on the proximal lobe are eight plumose setae. Externally

the proximal lobe is beset with long setae, of which only a few (12) of the more distal are plumose.

Upon the flattened face of this proximal lobe there is in one specimen a slight ridge, set with setae running obliquely inwards from the lateral border. It has the position of the ventro-mesial border of the epipodite of succeeding pleopods and might conceivably indicate the fusion of an epipodite with that plate. The basal joint (protopodite) has stiff plumed setae on its mesial border only, whereas the basal joint of the first pleopod has numerous setae both mesially and externally. Upon pleopoda 3-5, the epipodites are free and of relatively large size; the endopodites are long, extending to the base of the distal exopodite segment; the basal joint (protopodite) with a mesial lobe set with long setae. Upon the proximal exopodite joint of the third pleopod the number of plumose setae is increased to about 25. In life the pleopods are visible, their distal ends coming well below the inferior margin of the pleura of the pleon segments.* The ventral margin of the pleon segments 1-5 are fringed with long flexible setae which scarcely extend onto the posterior borders. Upon the sixth segment (Pl. XXIX, fig. 42) these seta are represented by serrations or short pectinate spines which give place posteriorly to a few (3-4) stout spiniform setae. The pleura of the latter segment slightly overlap the telson externally and are fused with it. The line of suture is quite distinctly raised and gives origin to but three delicate setae.

The *uropods* (Pl. XXV, fig. 1, and Pl. XXIX, figs. 42, 43) are well developed, a stout peduncle projecting backward to the level of the end of the telson. Ventrally there are two tufts of three setae, dorsally three or four almost equi-distant spines upon the outer border (fig. 43); two stouter spines upon the inner margin at its distal end (fig. 42).

At the extremity of the peduncle one or two spines are laterally placed, while ventrally are three spines—the innermost simple (fig. 42a), the middle very stout, with terminal pectination dorsally, and the outermost, smaller but also with terminal pectination (Figs. 43, 43a).

The rami are of nearly equal length, the outer slightly the shorter; each bears an apical spine and two or three setae, but the whole appendage is distinctly less setose than is usual in this genus.

*This is the case with all of the species of *Phreatoicus* that I have been able to examine in the living condition. In many preserved specimens also, the pleopods may be seen hanging downwards and then quite obvious.

Upon the dorsal surface of the large *telson* the presence of a deep transverse rounded depression emphasises the upturned end, which bears a number of setae and is flanked ventro-laterally by a couple of stouter spines on either side (Pl. XXV, fig. 1, and Pl. XXIX, figs. 40, 41).

While the telson as a whole is concavo-convex in section, this tip-tilted terminal part has, in cross section, the shape of a long ellipse.

Remarks. This, the third sub-alpine species to be recorded from Eastern Australia, is in many ways intermediate between *P. australis* and *P. shephardi.* So much is this the case that when, at first, I thought of the Mt. Buffalo form rather as a variety than a species, I could not decide to which of the two it should be referred. I have not, however, been able to examine any examples of *P. shephardi,* and the descriptions given by Sayce (1900) and by Chilton (1916) are too brief to make possible a detailed comparison between the two Victorian species. Judging from Smith's figures (1909, Pl. 12, figs. 1-4) the Tasmanian forms of *P. australis* are somewhat variable, and it may later become necessary to reduce *P. joyneri* to the rank of a variety of *P. australis,* but for the present it seems advisable to regard it as distinct.

The proportion of length of pleon to that of combined cephalon and peraeon is almost exactly that given by Sayce for *P. shephardi,* but this ratio, according to Chilton, holds only for the female (and, presumably, for the immature male) of that species. The spinous condition of the ventral margin of its 6th pleon segment, likewise, resembles closely that of *P. joyneri;* in the latter, too, the sutural line between the 6th pleon segment and telson is shorter and less distinct than in *P. australis;* in *P. shephardi* it is presumably absent, being neither figured nor described. The peduncle of the second antenna, inner lobe of the second maxilla, propod of first, fourth and seventh peraeopods in the male of *P. shephardi* all approximate closely to the condition found in *P. joyneri.* The pleopods of the former species are not described.

From *P. australis,* the new Victorian Phreatoicid differs in its larger size and more robust habit, its smooth body almost free from setae, the proportions of the pleon, the more elongated peduncle of the second antenna, the condition of the spinous plate of the left mandible, the more setose lower lip, the tufted condition of the plumose setae on the inner lobe of the first maxillae, the shape of the inner lobe of the second maxillae, certain details in the three posterior legs, the endopodites of the pleopods, the less spinous condition of the uropods, and the shape of the outline of the inferior margin of the telson.

In the possession of but very few joints in the first antennae, of a well marked vertical groove near the posterior border of the head, and of stout pectinate spines at the base of the rami of the uropods, in the well developed condition of the coxae of the peraeopods, and the pronounced terminal projection upon the telson, it agrees with *P. australis* and seems to differ markedly from *P. shephardi*.

In the reduction of the size of the eye and the fewness of the ommatidia, it represents a condition intermediate between the two Eastern Australian forms; in the smoothness of the body and the reduction of the setae it approaches the condition of *P. assimilis*, a state resulting probably from the operation of somewhat similar sheltered conditions of life.

Distribution. While *P. australis* occurs apparently widely spread in Tasmania at altitudes varying from sea-level to 4,000 feet, upon the mainland it seems to have survived only upon Mt. Kosciusko (5,700 ft.). *P. shephardi*, first recorded from the Plenty Ranges in Southern Victoria, was subsequently taken, apparently abundantly, upon the Barrington Tops, in New South Wales, some three to four hundred miles to the north. *P. joyneri* occupies a small sub-alpine region within the range of both of these forms. It is probable that all of these species are survivors of a once wide spread form living at lower levels, but later restricted, possibly due to secular climatic changes, to small and isolated sub-alpine regions where they have undergone specific differentiation.

EOPHREATOICUS gen. nov.

Body scaly, wrinkled transversely; head short, with well marked vertical groove near posterior margin; eyes large; peraeon slightly compressed, first segment short, more or less fused with the head; pleon relatively longer than in *Phreatoicus*, strongly laterally compressed, last segment scarcely marked off from telson, terminal projection slightly developed. Upper antenna as long as (longer than) peduncle of lower antenna, flagellum with numerous joints; lower antenna stout, about one-third length of body. Mandibles with appendage, secondary dentate cutting edge, spine row and molar tubercle. Legs divided into an anterior series of four displaying small coxal joint, and the meros with large anterior lobe; and a posterior series of three, with basos, ischios and meros strongly expanded. First pair of legs sub-chelate in both sexes, larger in the male than in the female, the fourth leg in the male sub-chelate. Pleopoda with exopodite and endopodite sub-equal, with epipodite on all but the first, without coupling hooks; with curved penial filament on second pleopod strongly setose, not exceeding endopodite. Uropod stout, slightly expanded, biramous, very setose. Telson,

horse-shoe shaped in transverse section, with margin entire, not up-turned.

E. kershawi, sp. nov., Plates XXVII, XXVIII and XXIX, Figs. 34-39.

Specific Diagnosis. Body robust, surface scale clad with very few scattered hairs, dorsal surface transversely ridged; head considerably shorter than combined length of first and second peraeon segments and with strongly marked vertical groove near posterior border. Eyes well developed, strongly convex, with many ommatidia. Peraeon distinctly compressed, first segment narrow, widening somewhat ventrally, scarcely free from head; second, third, and fourth segments sub-equal, coxal plates small. Fifth, sixth, and seventh segments decreasing progressively in length, coxal plates scarcely distinct. Pleon long, having with telson a length slightly greater than four-fifths of that of combined cephalon and peraeon and a greatest depth equal to the combined length of third, fourth, and fifth pleon segments. Two or three stiff setae on ventral margins of pleon segments; without setae on posterior margins. Sixth segment fused with telson, with but very short sutural line which bears no setae. Telson large, horse-shoe shaped in transverse section, without up-turned terminal projection, margin entire, with four stout spinules.

First antenna stout, longer than peduncle of lower antenna, with as many as sixteen articuli, with sensory setae, but no olfactory cylinders; peduncle and proximal joints of flagellum with serrate margin (due to scales). Second antenna, two proximal joints stout, sub-equal, third and fourth slightly longer, sub-equal, fifth slender, long as third and fourth combined; flagellum with as many as twenty-two joints, somewhat longer than peduncle; margin of entire appendage serrated. Right mandible with reduced and modified secondary dentate cutting edge, with spine row, molar tubercle with setae, palp with broad second joint. Lower lip extremely setose, scale-covered. First maxilla, inner lobe with seven plumose setae and one simple seta. Second maxilla, short and stout, inner plate sub-triangular, outer plate and palp with mesial margin reflexed distally. Maxilliped with two strong plumose setae on distal end of second joint, just internal to inner plate, the latter with row of 4 or 5 coupling hooks. Gnathopod with stout rounded basos, large ischios, propod strongly convex anteriorly, palm set with stout spines, occupying entire posterior margin; dactyl long and straight, but sharply bent near base, with minute secondary unguis. Second, third and fourth peraeopods with stout rounded basos bearing anteriorly at the proximal end a small tuft of stout setae; ischios widest mesially owing to flattened expansion, meros produced into conspicuous antero-distal lobe, dactyl with secondary ungnis. In the male, fourth peraeopod sub-chelate, a pair of stout

spines on propod receiving tip of dactyl. In the posterior series of peracopods, the length of the limb and the extent of the expansion of the three proximal joints increases progressively, the meros being produced into a notable distal lobe. First pleopod with endopodite and exopodite of equal length; pleopods 2-5 with endopodite overlapping distal joint of exopodite and with epipodite. Second pleopod, in male, with penial filament, moderately curved, concave laterally, strongly setose with a considerable row of stout setae apically. Uropod stout, peduncle expanded on inner margin, very spinose on both margins; rami expanded, spinose, inner the longer. Spine at base of rami not pectinate.

Colour: In spirit, yellowish-grey. The body generally is yellow tinted, with black dendritic spots scattered sparsely along the sides and still more sparsely upon the extremities of the limbs. In mid-dorsal line and on either side dorsally, these spots are closely aggregated to form three dark interrupted lines. In the peraeon these may be continuous and almost merge into one another, the marking then, in that region, may be described as consisting of a paired dark dorso-lateral line separated by a light median yellow line bearing a dark spot at the middle of each segment. Laterally (externally) the dark bands may be defined by a thin and wavy yellow line.

Size: The largest male measured 21 mm., the smallest but 12 mm., with a width of peraeon of 2.5 mm. About 25 per cent. of the specimens showed no male organ, the largest of these being 14 mm. in length, with a breadth of peraeon of 3.5 mm.; the smallest obtained measured 9 mm.

Locality: The collection of close upon a hundred specimens was made by W. McLennan (in November, 1915) and was presented to the Museum by H. L. White, Esq. The locality label indicates that the specimens were taken in a "small pool" at "Sandstone Bluff," Northern Territory. From notes, made by the collector, it would appear that the spot was on, or near, the Wellington Hills, E. long. 133½°, S. lat. 12°. In other notes, kindly supplied by Mr. Kershaw, the pool is described as "a fine rock hole of clear, cool water."

Detailed description. This species apparently attains almost to the largest size recorded for living aquatic Phreatoicids.* Of the mature ovigerous female there are no specimens, the largest female in the collection reaching a length only two thirds that of the largest male. In this respect, this species appears to agree with

*Its length is equalled, perhaps exceeded, by large examples of *P. kirkii*, var. *dunedinensis*, Chilton, which is said to reach 22.5 mm., and by *P. spinosus*, Smith (15-25mm.). My largest specimen of *A. lintoni* measured 20 mm. The fossil form *P. wianamattensis* had an estimated length of 30 mm.

members of the genus *Phreatoicus*, whereas in *Amphisopus* the female is nearly as large as the male or may even considerably exceed that in length.

The *body* (Pl. XXVII, fig. 17) as a whole, appears to be covered with tiny flattened setae or scales, which seem to vary in shape from a broad triangular to nearly semi-circular, this covering giving everywhere to the body and largely to the appendages, when seen in profile, a serrated margin. This cannot always be made out at the extremities of the limbs, and is less evident on mandibles and maxillae, but is clearly visible on flattened surfaces of lips, inner plate of maxillipeds, etc. In addition to the scales, the body appears to have a scattered granulation, but the fine short setae that furnish a thin fur-like covering for the body in other species of *Phreatoicus* appear to be entirely absent.

A transverse corrugation of the surface is well marked, though less developed than appears, from Geoffrey Smith's figures, to be the case in *P. spinosus* and other Tasmanian species. In all of these latter, too (including *P. australis*), Smith notes a serration of the antennae which is probably due to a retention of scales upon those appendages, although this is not stated. In the mainland species of *Phreatoicus* and in *Amphisopus* the scales have apparently disappeared.

The body attains its full width at the level of the second peraeon segment and maintains a practically uniform thickness to the second pleon segment, behind which there is but a very gentle tapering to the end of the body, so that although the pleon is quite deep, its depth is nevertheless only $1\frac{1}{2}$ the thickness of the body in that region.

In yet another of the proportions of the body, this species is probably generalised—the length of the pleon and telson is rather more than four-fifths of the length of combined cephalon and peraeon, a condition contributed to partly by the unusual shortness of the head, but chiefly attributable to the relative uniformity in the length of the body segments. Measured along the mid-dorsal line the pleon and telson together have a length equal to that of the seven free peraeon segments.

The head is strongly convex dorsally from side to side, and in profile is almost the quadrant of a circle. The eye is very well developed, forming a hemispherical prominence with probably not less than one hundred ommatidia. The inferior margin of the head is slightly produced postero-laterally, where it touches the maxilliped. From the posterior margin, a well defined groove runs upward nearly to the dorsal line. In *P. australis*, this is stated to actually make a well defined transverse groove; in *P. joyneri* and *P.*

assimilis it is not completely transverse; in *P. shephardi* and *P. typicus* it is not figured, nor is any reference made to its presence in *P. kirkii*. G. Smith likewise makes no mention of it in his account (1909) of the Tasmanian species. In *P. typicus* I should rather expect it to have disappeared, but it will be surprising if it proves to be absent in the other species of *Phreatoicus*. In all three species of *Amphisopus* it is certainly wanting, but, as Chilton has pointed out (1891, p. 153) a quite similar groove is present in many species of *Idotea*, and it is reasonable to suppose that it marks the suture between the first peraeon segment (the maxilliped segment) and the head, a segment free in the Anaspidacea, but incorporated in the head in *Koonunga* and Isopods generally, all traces of its original anterior boundary having been lost in most of the members of this latter group. The first free segment of the peraeon of *Phreatoicus* is also by way of reduction and incorporation in the head, a condition which has actually come about in the Tanaidae.

In the peraeon the coxal joints are greatly reduced and the antero-ventral corner of the several segments is distinctly produced in front or perhaps is coming to lie external to the coxal joints. In the hinder series of legs a posterior cleft only partly defines the joint, which has become flattened externally and incorporated with the ventral margin of its related segment.

The pleon segments are relatively deep and unusually wide, the ventral borders almost and the posterior borders quite free from setae. The fifth segment is deeply notched behind and is slightly shallower than the segment immediately preceding; the sixth, marked off from the telson only by a short suture running almost vertically upward from the point of origin of the uropod. It makes with the telson a large piece terminating (Pl. XXIX, fig. 39) in a rounded projection which is not upturned as it is in most of the species of *Phreatoicus*. Its margin is entire and it is flanked laterally by a paired projection bearing a stout terminal and a slighter lateral spine. Ventrally the margin of the telson bears on either side one large spine and a much smaller spinule.

Appendages. The *first antenna* (Pl. XXVII, fig. 18) is well developed, the peduncle scarcely differentiated from the flagellum; the basal joint is large, the second as long but more slender, the third shorter, and little stouter than the proximal article of the flagellum. The flagellum may have as many as sixteen joints, nearly oblong in outline and diminishing fairly regularly in length, the terminal joint, however, being a mere knob. Sensory setae (Fig. 18, s) occur on most joints, but the "olfactory setae" so characteristic of *Phreatoicus* could not be recognised.

The *second antennae* (Pl. XXVII, fig. 19) are stout, of quite moderate length, with well defined peduncle (of a length approxi-

mately equal to the first antenna), of five joints, of which the slender fifth is much the longest. In profile, the flagellar joints are squarish, but a few of the more distal are quite slender; each is incompletely encircled by setae.

Neither upper nor lower lip calls for special comment. The *left mandible* (Pl. XXIX, fig. 34) has an outer cutting edge of four teeth and an inner series of three; immediately proximal to this latter is a curved spine row and beyond this the lower margin is setose. A well developed palp is present, the second joint, much the largest, being both broad and long. In the *right mandible* (Pl. XXIX, fig. 35) the outer dentate row shows three teeth only, the inner edge seems to be divided into two teeth, both of which are curiously denticulate, the denticles in their turn pectinate. In the natural position, this inner edge underlies a spinous row. In the figure, the molar tubercle is seen in profile and has two slender setae on its grinding face; internal to its base are numerous setae.

The *first maxilla* (Pl. XXVIII, fig. 29) is stout, the outer plate setose both laterally and mesially, and armed with an apical tuft of 10 or 11 stout pectinate spines in the usual double row, some being pectinated on both edges. The inner plate is strongly setose distally and upon its truncate apex bears seven terminal plumose setae, with one simple seta at its external end. Some of the plumose setae are of the type usual in *Phreatoicus*, but towards the mesial side some are apparently undergoing reduction, approaching a unilateral condition.

The *second maxilla* (Pl. XXIX, fig. 36) is also stout; it shows the inner plate triangular and closely set with bent setae (distally directed), along the entire mesial length of one edge of its border, which is apparently flattened, from the other edge projecting a series of stiff, feebly ciliated setae. At the apex the two series meet and pass into a terminal tuft of curved, plumed and pectinate setae (some plumose on one side of the axis and pectinate on the opposite). The palp appears to have a well defined joint and the entire outer border of the appendage is setose.

Maxilliped (Pl. XXVIII, figs. 27, 28). The epipodite is nearly round, with a few short setae inserted into its serrated outer margin, its mesial margin strongly setose. The second joint of the appendage bears two stout plumose setae and the mesial border of the inner plate is fringed with similar setae, which pass at the truncate apex into stiff curved setae. These are doubly, and then singly, pectinate, and at the external angle become more curved, passing by an easy transition into a series of five coupling hooks—strongly

re-curved, with a forked apical hook and more proximal curved pectinations (fig. 28e); the scaly surface is well seen here.

The *gnathopod* (Pl. XXVII, fig. 20) is of the usual type, the propod unusually strong, the palm straight, extending along the entire posterior border of the joint; both ischios and meros are expanded and produced anteriorly into a lobe which is prolonged by a stout spine, the lobe of the meros being directed almost proximally. In the three succeeding appendages, also, these joints are notably produced, such considerable development of the meros being met with, so far as I can discover, in no other extant species of the Phreatoicidea. In the fossil form *P. wianamattensis*, however, a similar condition is clearly shown, Chilton (1918), calling particular attention to this feature (l.c., p. 368).

The *fourth peracopod* (Pl. XXVII, fig. 21) is sub-chelate in the male, as in all species of *Phreatoicus*, differing in this from *Amphisopus*. It is noteworthy that in the perfectly preserved fourth peracopod of *P. wianamattensis* there is no suggestion of a sub-chelate condition, but the impression may, of course, have been that of a female.

The *fifth*, *sixth*, and *seventh peracopods* (Pl. XXVII, figs. 17, 22) show a rounded basos with a marked posterior plate-like expansion and a similar expansion is developed on ischios and meros of both the hinder appendages. In the fossil form a similar expansion is indicated (though less developed) in Chilton's figures 1, 2, 3, 7, and 10, and it is noteworthy, also, that in this species the ischios is relatively much shorter than is usual in this genus. In this extinct form, too, it may be noted that the segments seem to have had a much more uniform length.

The male appendage (Pl. XXIX, fig. 38) is a curved structure, relatively short and stout, bearing a few setae on its anterior (more convex) border and with evident serrated margin.

Pleopods. In the appendages of the pleon, the first point to be noted is that, in all, the two rami are approximately equal, in the sense that the endopodite extends distally practically as far as the exopodite, a condition found elsewhere, so far as I can discover, only in *A. latipes*. Further, in all but the first of these appendages a large epipodite is present. In two of the specimens examined I failed to find an epipodite upon the *third* pleopod, but the plate is very easily detached and possibly was lost in removal. In none of the specimens examined was an epipodite lacking from the second pleopod, having there a sub-triangular shape; on succeeding appendages this plate is much larger and roughly quadrangular, fringed

with long setae, the postero-lateral corner crenate, with more closely set setae.

The endopodites are, as usual, thin transparent laminae without fringing setae, the exopodites (with the exception of that of the first pleopod) divided into a large proximal and an unusually short distal lobe. This latter is almost completely fringed with plumose setae, such setae being continued proximally along the greater part of the lateral border of the proximal lobe, passing presently into simple setae. On the mesial border a very few of the distal setae may be plumose, but the greater number are simple and these may extend from the edge on to the face of the plate as a thick bordering tuft (Pl. XXVII, fig. 25, ex.). In the male, the endopodite of the second pleopod is differentiated in the usual manner to form a penial filament. This consists of a stout basal piece and a semi-cylindrical distal portion, somewhat curved, concave laterally and fringed along both margins with fine setae. At the apex these pass into a curved line of exceptionally stout setae to form a conspicuous terminal tuft (fig. 26, s.).

Both rami, and the epipodite when present, spring from a basal piece or peduncle of rather indeterminate shape. In both first and second pleopods, however, it is bilobed and suggests a two-jointed structure; in the case of the first pleopod (Pl. XXVII, figs. 23, 24) long setae are present on both lobes mesially. On the lateral border but a single lobe is indicated. As regards size, the first pleopod is the smallest, the second somewhat larger, the third largest (Pl. XXVIII, fig. 31), the fourth and fifth progressively smaller (Pl. XXVIII, figs. 32, 33).

The *uropods* (Pl. XXIX, fig. 37) consist of a stout, relatively short peduncle, expanded dorsally on its inner border, both borders being produced into a continuous line of spines and setae. The inner ramus is also expanded and set with spines, the slightly shorter, outer ramus less expanded. Ventrally to the origin of the rami are a couple of setae, one being quite stout, but neither are pectinated as in *Phreatoicus*.

Notes on the Habits of some of the Phreatoicidea.

Geoffrey Smith, referring to the habits of the Tasmanian species of *Phreatoicus*, remarks (1909, p. 71):—"Their movements are exceedingly sluggish, so that when alive they are easily distinguished from the rapidly moving Amphipods . . ." Of *A. palustris*, which I have kept under close observation for some time, it may be said that while they normally creep about slowly or lie upon the side at rest (their colour harmonising wonderfully with that of the debris upon, or beneath, which they rest while feeding, and rendering them almost invisible), if disturbed they are capable of swift

movement, swimming rapidly with a quick, scurrying motion (effected apparently largely, if not entirely, by the uropods), remarkably like the jerky movement of an Amphipod. Indeed, a small specimen may readily be mistaken, in its sidewise motion, for an Amphipod. Like an Amphipod, too, it may swim in the erect position, this, by the movement of the pleopods. The larger Western Australian form is, perhaps, slightly less agile.

Glauert notes of *A. palustris* (1924, p. 49):—"The animals are fairly active and exceedingly quick at burrowing into the soft muddy bottom . . . . when not burrowing (they) prefer dark or shady corners. Their food seems to consist of animal and vegetable matter, and they make most effective scavengers." I have offered small portions of dead earthworms, insect larvae, etc., but have never observed that this material has been touched. The preference for dark spots is particularly noticeable in the females, and, in rounding up my specimens, those are practically always the last to be secured.

Pairing seems to extend over a comparatively long period, couples taken together have so continued for fifteen days subsequently, the brood pouch enlarging visibly during that period. In a small female of about 11mm. the brood were discharged on the twenty-eighth day after the separation of the pair, no fewer than fifty-one young issuing at that time. The male of this pair underwent ecdysis a couple of days prior to the emergence of the young, but the female had not shed her skin four weeks later when she was again pairing.

The process of ecdysis must have a considerable importance to these animals, even when full size is attained, if they are living in a comparatively small water hole, for, under such conditions, they become thickly covered with encrusting organisms, even to the plumose hairs of the pleopods. In *A. palustris* a small Vorticellid is very common and occasionally a Dendrocometes-like form may be found, best seen on the cast skin and apparently most affecting the antennae and the gnathopods. Barnard notes a similar infestation in *P. capensis* by "a short-stalked Infusorian," while Chilton, also, remarks upon the heavily infested condition of *P. australis*. The dense covering of Rotifers, etc., in *P. joyneri* has been mentioned above. That the instinct for concealment is apparently more strongly developed in the female is probably the explanation of the fact that collections usually contain a large preponderance of males unless the collecting has been accomplished by an indiscriminating use of the scoop or net in the muddy or weed-grown hiding places. Thus Chilton (1891, p. 165) notes of his material of *P. australis*, "nearly two-thirds were undoubtedly males." In the collection of *Eophreatoicus* which I have examined at least three-quarters were

males, and in *P. joyneri* (where I took all that I could see) at least as large a proportion are of this sex. Of the *Hyperoedesipus* in my collection probably less than 5 per cent. are females, while of *Hypsinetopus* there is no record of the capture of females. The early collections of *Phreatoicopsis*, also, consisted wholly of male specimens, but it should be noted that, in most, if not all of these species, the male is the larger as well as less prone to concealment. In *Amphisopus lintoni*, on the other hand, my material showed an overwhelming preponderance of females. In this case, however, the female attains to a size nearly twice that of the average male, and is perhaps less able to effectively conceal herself. In the partly grown forms it is often not possible to distinguish between immature male and female by inspection only, and the disproportion in numbers between the sexes may not be as great as would appear from the composition of a given collection. In *P. typicus* the male is apparently unknown.

In pairing, as Glauert has noted (l.c.), the male of *A. palustris* makes use of his strongly developed gnathopods, the fourth pair of peraeopods not being especially modified in this genus. I have observed, however, that the rather hook-like peraeopods of the anterior series, may all, at times, be caught under the projecting epimera of the female. The structure of the second and third peraeopods of *P. joyneri* suggests that these have a somewhat prehensile character.

Of *Hyperoedesipus* it is worthy of note that the remarkably developed gnathopods of the male seem never to be used for this purpose, the hold being effected entirely by the fourth pair. An obvious explanation is, however, at once forthcoming. The greatest danger to which a blind, subterranean form such as this could be exposed, is that of being swept irrevocably to the surface, there to be washed out to sea, or, escaping that, almost certainly to perish in competition with, or a prey to, surface-living forms.* During pairing, when a double strain might be imposed upon its earth hold, there is clearly a need, *in the male*, for a greater muscular development of its gripping appendage. I have never seen *Hyperoedesipus* feeding on animal matter, and I believe that the great gnathopods are *not* raptorial. The fourth peraeopod appears to be but slightly

*In the tiny hollow, in which alone I have found these forms, they have been associated with three other obviously underground forms (a small Amphipod, a planarian, and a minute earthworm, probably a Phraeodrilid), from none of which would they be likely to have much to fear in their subterranean haunts, excepting only for the competition for such food as there may be.

prehensile in *P. assimilis*, so that in this species one must suppose the gnathopods to be used in pairing. It would be of interest to know whether in *P. australis* and other surface-living forms the fourth peraeopod has superseded the gnathopod in this function or is merely auxiliary thereto.

A comparison of the size of the brood in *Amphisopus* and *Phreatoicus* is of interest. In *P. shephardi*, which reaches according to Sayce (1900) a length of 10mm., Chilton records that the brood pouch contained a dozen eggs, while from the pouch of an 11mm. specimen of *A. palustris* I have collected more than fifty just emerged larvae. In a second case there were counted forty-eight living young and one dead. From the brood pouch of *A. lintoni* there were extracted thirty-five large embryos. These facts suggest that adaptation to sub-alpine life has resulted not only in a stunting of the growth, but in a diminution, also, of the reproductive capacity. In none of my specimens of *P. joyneri* or *E. kershawi* do the brood pouches contain eggs or embryos, and nothing has been recorded for other members of the family. The accommodation of the body to subterranean life will probably have restricted still further the number of the offspring. In *Hyperoedesipus*, of which very few females have been taken (probably for the reason suggested above in the case of *A. palustris*), the normal number of eggs is round about four, though in one which paired in an aquarium, seven eggs were seen in the pouch when the animal was killed.

In *A. palustris* the embryos were a full 2mm. in length at the time of their emergence, with the six pairs of peraeopoda usual in larval Isopoda. The body was almost transparent, of a palely brown tint, and a large proportion of the larvae appeared to bear one or more of the infesting stalked Infusorian, these having evidently spread on to the young while still within the brood-pouch. The embryos of *A. lintoni* were more than 1½mm. in length when as yet only the rudiments of the limbs could be discerned, and it is probable that the larvae would be at least twice that length. The first antennae were short, consisting of a three jointed peduncle and a slightly clubbed flagellum with five joints, somewhat closely resembling the condition in adult *P. australis* or *P. joyneri*, which might be interpreted as evidence that, in this appendage, the sub-alpine forms have retained very nearly the larval condition.

After twenty-four days, the young died off quite suddenly, perhaps approaching the critical period of the first moult.

The brood pouch is composed of four pairs of lamellae, the first (internal to the gnathopods) being unequally bilobed, the anterior lobe the smaller and making up much of the anterior wall of the pouch. In all of these lamellae there is a central stouter axis, around which is a broad and transparent margin (respiratory ?),

fringed with numerous setae. In the full sized males of *Phreatoicopsis,* there is a similar but smaller set of these lamellae, which are hard (appearing calcified) and lie closely adpressed to the ventral thoracic wall, of which they might be taken for mere thickenings. These appear to have been altogether overlooked in earlier descriptions of this form.

THE POSITION OF EOPHREATOICUS IN THE PHREATOICIDEA.

Eophreatoicus kershawi, the type of the new genus, is remarkable among known Phreatoicidea in the possession of a scaly covering, although, as pointed out above, it is possible that several species will be found to have retained vestiges of this condition.

A slightly wrinkled state of the body is described by Chilton as occurring in *P. australis* and is plainly figured by Smith for several Tasmanian forms. Barnard does not mention it as characteristic of *P. capensis,* and in all the species of *Amphisopus* the body is wholly free from wrinkling, nor does it occur in the subterranean (New Zealand) species of *Phreatoicus* and the allied subterranean genera.

The shortness of the head seems peculiar to this form, but is approached in *A. palustris.* The retention of large and prominent eyes, like those in *Amphisopus,* is doubtless indicative of continuous occupation of surface waters, the reduction of the eyes or the blind condition of the several sub-alpine or subterranean forms having, perhaps, arisen independently in those forms.

The vertical groove upon the head which, in my opinion, is to be regarded as the last evidence, in this family, of an originally free maxilliped segment, has already completely disappeared in *Amphisopus.* It is well developed in *E. kershawi,* in *P. capensis, P. australis, P. joyneri, P. assimilis* and, therefore, presumably in *P. kirkii* (vide Chilton, 1906, p. 274); very probably, too, in the several Tasmanian species, though Smith makes no reference to it in his descriptions, but then he does not figure it in *P. australis,* in which Chilton had previously described and figured it. Similarly has Sayce (1900) omitted all mention of this structure in *P. shephardi,* where it may perhaps be absent. If, however, it prove to be present in the Tasmanian forms and in *P. shephardi,* as I should expect, then *P. typicus,* alone in this genus, would be without it, but would share this peculiarity with *Phreatoicoides, Hypsimetopus* and *Hypcroedesipus.* All of these forms have a striking resemblance to *P. typicus,* a likeness most readily to be explained by the suggestion that they all have their descent from a common blind ancestor already adapted to life in subterranean waters, which in its turn had derived from a surface living form. That such surface-living forms existed at a time while yet there may have been land communications between Australia, Tasmania and New Zealand is practically established by

the discovery of those well preserved Phreatoicid fossils from the Triasic beds of N.S.W.

In the possession of filiform and relatively long first antennae, *Eophreatoicus* is again in agreement with *Amphisopus* and in strong contrast with *Phreatoicus* and the group of subterranean genera; in this particular, *P. capensis* is in agreement with the Australian and Tasmanian forms (with the possible exception of *P. spinosus*).

A nearer approach to uniformity in the length of the segments (except the first free peraeon segment) and, as a consequence, the possession of a relatively long pleon-telson region, must be accounted as a primitive character in *Eophreatoicus.** In *P. spinosus*, the development of this region is said to be even greater, being, according to Barnard (1914, p. 239), no less than 99 per cent. of the length of combined cephalon and peraeon. In this latter species, however, there is a remarkable development of the terminal telsonic projection, which adds the equivalent of the length of a segment to this region. Generally in the Phreatoicidae the tendency is towards a reduction of the pleon region, a tendency which has become very pronounced in the Isopoda as a whole. In the members of this family, the pleon-telson region, expressed in terms of the percentage length of combined cephalon and peraeon, offers a series displaying increasing reduction. *E. kershawi*, 80%; *P. tasmaniae* and *P. capensis*, 75%—70%; *P. joyneri*, *P. shephardi*, *P. kirkii*, *P. australis*, *P. assimilis*, *P. typicus*, in a bunch varying from 66%—58%, and *P. kirkii* var. *dunedinensis* to 45%. In the related subterranean genera an even greater reduction is attained. In *Hyperoedesipus* the figure is 53%, in *Hypsimetopus*, 45%, and in *Phreatoicoides*, 36%. While agreeing with Chilton's remarks (1906, p. 275) that measurements of this kind are not easily made with the same accuracy in all cases, and may vary to some extent in different individuals, I am of opinion, nevertheless, that such a series of stages in the reduction of the terminal body region as is found in the family is not without a distinct significance. In a form living in surface waters, *A. palustris*, as I have stated above, while the anterior peraeon appendages are largely functional in walking, aided (among debris), by the upturned, backwardly directed and more elongate legs of the hinder series—for swimming the animal relies upon the pleopods with or without the uropods, the deep pleura having a definite importance in this method of locomotion. In subterranean Isopods, if one may judge from *Hyperoedesipus* and *Cruregens*, the animal creeps but does

*In that generalised from *Anaspides*, the pleon-telson practically equals the cephalon-peraeon in length; in *Koonunga* the pleon-telson would appear to be a trifle the longer, the maxilliped segment here completely merged in the head.

not swim, the importance of the pleon region thus being largely diminished. Perhaps, too, a rounded sub-cylindrical body is better adapted for negotiating the interstices through which the water percolates, for I imagine that the animals' habitat is rather in such crevices than in actual subterranean lakes, and their entrance into wells might readily be through imperfections in the walls. There can be little doubt that *Phreatoicoides* may be taken at the surface for precisely the same reason as that which brings up *Hyperocdesipus* occasionally. Similarly a significance attaches to Chilton's statement (1906, p. 273) regarding the first finding of *P. kirkii* in "places that have been well searched, for Mr. Thomson and myself, and probably many others, have made collections in this locality without coming across the specimens in question." It would seem likely that this subterranean form comes only accidentally and rarely to the surface. *Hypsimetopus* is definitely recognised, as is *Phreatoicopsis*, as a dweller in damp earth rather than in subterranean water,* the latter quite possibly coming to the surface occasionally, perhaps, nocturnally. It has, it may be noted, the more usual proportions of surface-living forms (pleon-telson 60%), and its retention of eyes would suggest that its burrowing habit has been acquired comparatively recently.

The mandibles in *Eophreatoicus* seem more complete than in either *Amphisopus* or *Phreatoicus*, but the former, in the retention of the secondary dentate edge of the right mandible (even though in a more reduced condition) seems to approach more nearly to the condition of *Eophreatoicus*. In this particular, *Phreatoicopsis* and *P. capensis* are in agreement with *Amphisopus*.

In the condition of the first maxilla, with numerous (*seven*) plumose setae on the inner lobe, we are met again with what is, in all probability, a primitive condition,† retained in *Amphisopus*, but undergoing reduction in *Phreatoicus*. *P. typicus*, however, is stated to have nine or ten of such setae, while *P. australis* has four or five (Chilton, 1894, p. 198, and 1891, p. 158); all other Australasian species of *Phreatoicus* have but four plumose setae, but in every one of these (excepting *P. typicus*) there are said to be one or two setae which are not plumose. In *Hyperocdesipus* there are four

*It has recently been noted of another group of Isopods, that *Haloniscus* (a saltwater form) has a damp-earth representative (*H. stepheni*), whose burrows may, perhaps, give it access to water percolating beneath the dry surface of the creek (Nicholls and Barnes, 1926).

†In *Anaspides* (vide Geoffrey Smith, 1909, pp. 507-511) this lobe bears numerous plumose setae, in *Paranaspides* eleven are figured (l.c. fig. 13), in *Koonunga* they are reduced to three.

with a number of simple setae, in *Phreatocoides* three and two simple spines. *Hypsimetopus* has a single spine, followed by a plumose seta and five others, pectinate and ciliate. *Phreatoicopsis* apparently has a large number (Spencer and Hall, 1897, p. 17). *Amphisopus* retains six or seven of these setae and again, in this, links up with *P. capensis*, which has four plumose, and two "plumose only at the tip."

Upon the outer plate of the appendage there are usually 8 or 9 setae in most Phreatoicids, but in *P. typicus* they are described as numerous (about 14 are figured); in *E. kershawi* I find eleven. A large number is similarly present in the Syncarida, *Koonunga* once more showing but a few. In the retention, then, of a large number of setae upon the lobes of the first maxilla, both *Eophreatoicus* and *Phreatoicus typicus* may be regarded as preserving the more generalised condition.

In the coupling hooks of the maxillipeds there is again a suggestion of a loss of parts, there being 4 or 5 in *Eophreatoicus*, 3 in *Amphisopus* and *P. australis*, 2 or 3 in *P. capensis*, *P. typicus* and *P. joyneri*, with but 2 in *P. assimilis*. In *Phreatoicopsis* the pectinate setae at the apex are said to continue down the outer border of the inner plate (as in *Eophreatoicus*), and basally are three strong setae which are not hooked.

The condition of the gnathopod "hand," with its straight, ill-defined palm and scarcely modified dactyl, may be regarded as displaying a primitive simplicity. Further, the largely expanded state of the meros is, as pointed out above, an unusual feature in living Phreatoicids, but strikingly seen in the extinct *P. wianamattensis*. Something approaching it is seen in *Amphisopus* and in *P. capensis*. Chilton's figures suggest that, in the fossil form, the basos of the anterior as well as of the posterior series of legs was expanded.

The apparent small size of the coxae, also seen in *Amphisopus*, should probably be regarded as due to reduction. The much more apparent condition of these structures in *Phreatoicus* may, however, be due to the lesser degree of development of the protective (epimeral) margin in burrowing and Cryptozoic forms, and a consequent greater exposure of these joints, but I am inclined to consider it as the more primitive condition.

A well developed sub-chelate condition of the fourth peraeopod in the male it shares with *Phreatoicus* and *Hyperoedesipus*, this condition being but slightly indicated in *A. lintoni*, and the modification of this appendage is not much greater in *P. capensis*. In *Amphisopus*, *Phreatoicopsis*, *Hypsimetopus* and *Phreatocoides* the appendage is apparently unmodified.

The persistence of epipodites upon *four* of the five pleopods furnishes still further evidence of the primitive condition of this form. The practical equality of the two pleopod rami would perhaps bear the same interpretation; a condition most nearly approaching this being found in *A. latipes*, *P. capensis* and *Hypsimetopus*. In other forms the endopodite shows varying degrees of development. A feature to which little attention has been called, but which, nevertheless, seems to be unique in this family, is the development of plumose setae upon the endopodite in *P. capensis* (Barnard, 1914, Pl. XXIV).

In the condition of the penial filament of *Eophreatoicus* there is furnished yet another linking character. Moderately curved, as long as its endopodite, and set with a conspicuous tuft of terminal setae, it exhibits a condition intermediate between that of *Amphisopus* (strongly curved, longer than the endopodite and without terminal setae) and that of *Phreatoicus*—little curved, shorter than the endopodite, and with a smaller tuft of terminal setae.

The absence of coupling hooks upon the basal joints of first and second pleopoda in *Eophreatoicus* is possibly primitive, and constitutes one distinction between this genus and *Amphisopus*, which alone, in this family, possesses such structures. What are perhaps comparable structures are seen on the basal joint of the second pleopod in *Koonunga*, and coupling hooks are somewhat widely and variably distributed throughout the Isopoda.

The expanded condition of the uropoda, both in peduncle and rami, of *Eophreatoicus*, is not met with elsewhere in the *Phreatoicidea*, and finds, perhaps, its nearest comparison with the condition in the Syncarida, where, however, the expansion is notable. In *Eophreatoicus* it is obviously only an expanded condition of a styliform structure.

The practical absence of a terminal projection to the telson is, on the other hand, a new point of agreement with *Amphisopus*, as also, with *Phreatoicopsis*, and indeed, the profile of this region in *Eophreatoicus* is strikingly like that of *P. wianamattensis*, but is, perhaps, not primitive, if the terminal projection is the vestige of the elongate telson of a Syncaridan-like ancestor.

A consideration of these several points justifies, I believe, the separation of the more typical Phreatoicids into at least three genera—of which *Eophreatoicus* may be regarded as occupying the central position* and from which may be derived, on the one hand, *Amphisopus*, and, upon the other, *Phreatoicus*, as exemplified by *P. australis*.

*Though possibly itself derived from some form nearer to *P. typicus* in general appearance.

The more robust habit of *Eophreatoicus* links it with the larger Tasmanian forms, with *Amphisopus*, and, also, with the still larger *P. wianamattensis*. *Phreatoicopsis* could readily derive directly from the extinct form.

Amphisopus differs from *Eophreatoicus* principally in the loss of certain structures, notably the scales, and the epipodite upon the second pleopod; in the development (or retention?) of coupling hooks upon first and second pleopods, the structure of the penial filament, in the more complete degradation of the coxae of the peraeopods, in the absence of the sub-chelate condition of fourth peraeopod in the male, and the greater degree of expansion attained by the basos of the hinder legs.

Phreatoicus, climbing from the plains to sub-alpine regions, has diminished in size, has retained into adult life the larval or juvenile condition of the first antennae. A less compressed peraeon and smaller tergites permit of a greater exposure of the coxae, the palm has become restricted to the more distal portion of the propod, the eyes have dwindled and disappeared, the expansion of the several joints of the peraeopods has undergone more or less retrogression, while the prehensile character of the fourth peraeopod of the male has, perhaps, become more evident. A synchronous, or perhaps an earlier, change of habit may be supposed to have led to the modification of the burrowing forms, and thence to the occupation of subterranean waters, a change which may reasonably be presumed to have come about independently at different times and places.

In favour of the alternative view, that a form somewhat closely akin to *P. typicus*, but still possessed of eyes, would more nearly resemble the ancestral condition, the following features in that species might be cited as primitive:—the large head, a first peraeon segment scarcely smaller* than the succeeding (well seen, too, in *Hypsimetopus* and *Phreatoicoides*, and less evident in *Phreatoicopsis*), well developed coxae, basos rounded and without expansion, first maxilla with numerous plumose setae on inner lobe and still more numerous spines on outer lobe (equally well seen in *Phreatoicopsis*), pleon little compressed and without marked pleura, and terminal telsonic projection. Further, a shortened condition of the pleon appears to be of very general occurrence in the Isopoda and might reasonably be presumed to characterise the primitive Phreatoicid. Sub-alpine forms surviving in widely scattered localities might well be extremely ancient (as the admittedly generalised *Anaspides*) and have given rise to newer forms in lowland country, stray specimens washing down from high levels, the survivors undergoing modifications in adaptation to their new conditions. The mountain forms

*In *P. capensis* actually *longer* than the succeeding segment.

upon the Australian mainland all live, apparently, creeping beneath moss in highly sheltered situations. In open waters, with more active life and probably a more abundant food supply, adaptation might bring about the larger body, the expanded joints as aids to swimming, larger swimming and respiratory pleopods, the consequent increased importance of the pleon and a greater fecundity. In this view the short, almost clubbed first antennae of the larval stage of Amphisopus would appear merely as recapitulatory, the scaly clothing as a flattening and shortening of the fine fur-like covering of setae of the highland forms. The setae of the basal joints of the pleopods could be transmuted to coupling hooks, as those upon the maxilliped (in *Eophreatoicus*) appear to have been.

Many of the more important differences to be observed between *Eophreatoicus* and the sub-alpine species of *Phreatoicus* appear, however, to be more reasonably interpretable as due to loss and retrogression in the latter genus. So far as it is possible to judge, the very ancient *P. wianamattensis* would seem to find its nearest living counterpart in *Eophreatoicus*.

In the consideration of this question the structure of the South African species (which must have been isolated from its Australian congeners for an immense period of time) has a distinct importance.

P. capensis Barnard is described as having the posterior vertical groove upon the head, the first antenna very short, and its flagellum with but five joints, coxae of peraeopoda quite distinct, fourth peraeopod of male sub-chelate, the basal joint of the first peraeopod is figured as setose but without coupling hooks, the second pleopod with penial filament curved only at the apex, short and with terminal setae, the telson with prominent terminal projection—i.e., it has the general facies of the Eastern Australian forms. The inner lobe of the first maxilla, too, has four plumose setae and two others retaining cilia only at their apices.

In the retention of a secondary cutting edge to the right mandible it differs from these species and resembles *Amphisopus*, *Eophreatoicus* and *Phreatoicopsis*. The pleon, too, is longer relatively than it is in *P. australis*, but not longer than in one or two of the Tasmanian forms and near to that of *Amphisopus*. In the extremely elongated condition of the first free peraeon segment it is nearest to one or two of the subterranean species.

It is possessed, however, of two features in which it is apparently unique, in this family:—(1) the retention of a vestige of the innermost lobe on the second maxilla, which is plainly figured by Barnard, but not referred to in the text, in which condition it most nearly approaches that of the Syncarida; and (2), the existence of plumose setae upon the endopodites of the pleopods—no other

Phreatoicid, so far as I can discover, having setae of any kind upon this ramus.

In view of all these facts, it seems probable that it will become necessary to create a new genus to receive the South African species, but upon the whole, *P. capensis* may be regarded as approaching most nearly to the Australasian sub-alpine forms, while retaining certain characters undoubtedly primitive, many of these linking up with *Amphisopus*, *Eophreatoicus* and *Phreatoicopsis*.

Apart from *P. wianamattensis*, no undoubted fossil Phreatoicid seems to have been recognised. I have had, unfortunately, no access to the work of Packhard, quoted by Geoffrey Smith, but that author's reconstruction of *Acanthotelson stimpsoni* would serve, almost without modification, for the ancestral Phreatoicid. The elongated head, body with thirteen visible segments practically of uniform size, the telson marked off from the last pleon segment, pleon-telson practically equalling cephalon-peraeon (the elongate telson but an exaggeration of that of *P. spinosus*), pleon probably not strongly compressed and without downwardly developed pleura, the first antenna filiform and moderately long, without accessory flagellum, the second antenna without scale, with no trace of stalked eyes, the first peraeopod by way of becoming a gnathopod, peraeopods without exopodite not yet divided into two series, with distinct coxae and little differentiation of more distal joints, pleopods with stout basal joint and equal lamelliform rami, the elongate, equal and highly setose rami of the uropods, a walking form, but probably capable of feebly swimming, such a form might much more justly be classed with the Phreatoicidea than with the Syncarida.

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EXPLANATION OF PLATES XXV—XXIX.

PLATE XXV.

All figures of *Phreatoicus joyneri*, sp. nov.

Fig. 1 Entire animal (male), in side view.
2 First antenna, male.
2a First antenna, female.
3 Propod and dactyl of second peraeopod of male.
4 Propod and dactyl of third peraeopod of male.
5 Propod and dactyl of fourth peraeopod of male.
6 Propod and dactyl of first peraeopod (gnathopod) of male.
6a Palm of gnathopod, more highly magnified, with a single spine of the same, much enlarged.
7 Seventh peraeopod of male.
7a Part of dactyl of seventh peraeopod, highly magnified.

PLATE XXVI.

All figures of *Phreatoicus joyneri*, sp. nov.

Fig 8 First maxilla.
8a Inner plate of first maxilla, more highly magnified.
9 Lower lip.
10 Second maxilla.
11 Maxilliped.
12 Left mandible.
12a Dentate edge and spinous plate of right mandible.
13 Male appendage.
14 Second pleopod of male.
15 Third pleopod of male.
16 First pleopod of male.

PLATE XXVII.

All figures drawn from male of *Eophreatoicus kershawi*, gen. nov. et sp. nov.

Fig. 17 Side view of entire animal.
18 First antenna.
19 Second antenna.
20 Gnathopod, with palm more highly magnified.
21 Fourth peraeopod.
22 Seventh peraeopod.
23 First pleopod.
24 Basal portion of first pleopod more highly magnified.
25 Second pleopod, with epipodite, exopodite, endopodite, and

penial filament.

26 Penial filament, with apex more highly magnified.

PLATE XXVIII.

All figures from male of *Eophreatoicus kershawi*, gen. nov. et sp. nov.

Fig. 27 Maxilliped.

28 Inner plate of maxilliped, more highly magnified, with coupling hook still more enlarged.

29 First maxilla.

30 Part of second peraeopod, showing expanded lobes on ischios and meros.

31 Third pleopod.

32 Fourth pleopod.

33 Fifth pleopod.

PLATE XXIX.

Fig. 34 Left mandible of *E. kershawi*.

35 Right mandible of the same.

36 Second maxilla of the same.

37 Uropod of the same, in lateral view.

38 Male appendage of the same.

39 Dorsal view of telson of the same.

40 Dorsal view of telson of *P. joyneri*.

41 Terminal projection of telson of *P. joyneri*, more highly magnified, in postero-dorsal view.

42 Sixth pleon segment with uropod and part of telson of *P. joyneri*, seen from within.

42a Ventral spines from end of peduncle, in same view, more highly enlarged.

43 Uropod of *P. joyneri*, in lateral view.

43a Ventral spines from end of peduncle of the same, more highly enlarged.

44 Proximal portion of second Antenna of *P. joyneri*.

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